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HUMAN ENGINEERING DESIGN CRITERIA FOR MODERN CONTROL/DISPLAY CO--ETC(U)  
MAY 80 W E WOODSON, C COBURN DAAK40-79-C-0145  
UNCLASSIFIED MFI-80-101(R) DRSMI/R5-CR-80-2 NL

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TECHNICAL REPORT RS-CR-80-2

HUMAN ENGINEERING DESIGN CRITERIA FOR  
MODERN CONTROL/DISPLAY COMPONENTS AND  
STANDARD PARTS

FINAL REPORT

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For

US Army Human Engineering Laboratory Detachment  
Systems Engineering Directorate  
US Army Missile Laboratory

May 1980



U.S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama 35898

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## SUMMARY

This report summarizes work performed under Contract DAAK40-79-C-0145, "Human Engineering Design Criteria for Modern Control/Display Components and Standard Parts".

The purpose of the study project was to develop recommendations for revision of MIL-STD-1472B to update sections dealing with control, display and related human-system manipulative interface requirements.

The study consisted of the following specific tasks:

a. Examination of compliance levels for various requirements to determine whether certain uses of the mandatory term "shall" is appropriate in terms of its effect on user performance, is necessary in terms of its effect on system performance, and/or is defensible in terms of the basis upon which a requirement was established.

b. Examination of other military standards and specifications for requirements that appear to conflict with similar requirements in MIL-STD-1472B to determine whether some modification of MIL-STD-1472B and/or other standards or specifications is warranted in order to avoid the necessity of repetitive requests for waiver of one requirement or the other.

c. Examination of MIL-STD-1472B for its currency with respect to modern component hardware usage in order to expand the Standard where necessary to cover newer products currently in use and/or expected to be in use in the near future.

d. Examination of specific, quantitative requirements for their correctness under all appropriate applications and recommendation of changes to correct errors, inappropriate applications, and/or to provide appropriate compatibility with similar values in other military documents which may vary slightly due to the fact they were developed at different times or by different individuals having slightly different objectives.

Based on the information developed in the above tasks, specific modifications, additions (and, in a few cases, deletions) to MIL-STD-1472B are recommended. These include not only modifications and additions to written portions of the Standard but also to tabular and illustrative material as well. These recommended changes and additions have been packaged in a separate volume as an addendum to this report. This was done not only to make these

recommendations more convenient for the procuring activity to review but also to make it easier to select and implement the recommendations in order to revise the Standard.

In addition to the detailed paragraph-by-paragraph recommendations relative to modifying contract-specified portions of the Standard which are presented in the separate addendum, suggestions are provided at the end of this report for revision to other parts of the Standard and for additional experimental research needed to produce data to improve the quality of criterion values in support of some requirements. For example, there is a lack of appropriate data upon which to establish female force limits comparable to the male force limits currently defined in the Standard.

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## Preface

MIL-STD-1472, "Human Engineering Design Criteria for Military Systems, Equipment and Facilities" is the primary reference for designers when they are dealing with human factors questions relating to design of human-system interface design. It is used not only to provide design guidance but also to measure design compliance.

As hardware state of the art changes it becomes necessary to update MIL-STD-1472, just as with any other hardware standard or specification. In addition, however, there are situations in which certain hardware specifications call out requirements that deal expressly with human engineering questions. In some instances these conflict with similar requirements in MIL-STD-1472 despite a continuing effort to maintain reasonable compatibility between MIL-STD-1472 and these other specifications. The present study has been conducted expressly for the purpose of providing recommendations for an update of MIL-STD-1472B as well as making suggestions for possible modifications of other standards and specifications that deal with the subject of control-display design.

A unique approach of this study has been to utilize the expertise of selected industrial human factors specialists to review proposed changes to MIL-STD-1472B. The purpose of this was to include the needs of military system developers as they attempt to produce products that are compliant with military human engineering requirements. These are the people who must cope not only with military standards and specifications but who often are required to extend the state of the art by utilizing new products and components. Such specialists often are more cognizant of inadequacies of a military standard than are others because they must interpret such requirements in terms of designs that may not have been considered when the requirement was originally written. Thus, although a basic requirement may be valid in principle, the manner in which it is written may not always "fit" a new system, subsystem or component design problem.

The following industrial specialists serving as an Ad Hoc review panel have been extremely helpful in critiquing proposed modifications to MIL-STD-1472B and suggesting changes to make these recommendations more realistic, applicable and/or pertinent.

Mr. Dick Clark  
Dr. James M. Ketchel  
Mr. Joseph E. Burke

Ford Aerospace  
Stanford Research Institute  
Vought Corp.

Mr. William J. Adams	Rockwell International
Dr. Arthur Kahn	Westinghouse
Mr. Rodney M. Woodward	General Dynamics
Mr. Eldon T. Winston	RCA Corp.
Mr. Chuck Geer	Boeing Aerospace Co.
Dr. Harry L. Wolbers	McDonnell Douglas Astronautics Co.

In addition, the authors also wish to acknowledge with gratitude the efforts of the members of the Tri-Services Committee for their most helpful guidance and assistance in obtaining documentation for review. The following persons participated:

Mr. Gerald Chaikin	Tri Services Committee Chairman
Mr. John Chipser	Army Representative
Mr. Jean M. Ring	Air Force Representative
Dr. Heber Moore	Navy Representative



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## INTRODUCTION

### Study Purpose

The purpose of this study was to examine carefully those sections of MIL-STD-1472B (and revision Notices 1 and 2) pertaining to displays and controls, as well as related sections, in order to determine and to recommend modifications necessary to meet the following objectives:

- a. Ensure that the compliance levels of requirements are appropriate in terms of importance, necessity and supportability from a cost-effectiveness point of view.
- b. Determine what serious conflicts appear to exist between related portions of MIL-STD-1472B and other military standards, specifications, or handbooks concurrently in use for military systems development and to recommend appropriate changes, either to this Standard and/or to other documents, in order to remove such conflicts.
- c. Identify areas in which the present Standard is deficient with respect to current and near-future hardware state of the art; i.e., new products that are being used and/or contemplated in new systems and prepare appropriate human engineering requirements with respect to these products to be considered for inclusion in a future revision of this Standard.
- d. Examine carefully all criteria (quantitative data) to determine the correctness or validity of both the older and newer requirements being recommended.

The ultimate product of the above review and analysis is a detailed set of recommended modifications for consideration in a future revision of MIL-STD-1472B. These modifications include such things as simple title or word changes in existing paragraphs; minor re-wording of certain paragraphs or requirements statements to make them applicable to a broader range of design applications and/or to remove certain confusions that could occur due to the manner in which a requirement is stated; the introduction of new or expanded requirements to cover not only new product applications but also to provide appropriate applications of older component concepts that for one reason or another were not addressed in the current statements; and, finally, modifications of or additions to tabular or illustrative criteria and examples provided to support specific criterion statements.

## Study Approach

The basic approach to the study has been an iterative process of document review and analysis, current standard material revision, new requirements material development, and revision via an Ad Hoc Committee review cycle. The latter activity is unique in that it has provided a broader intellectual and experience base than normally might exist within the staff of a single research group, e.g., Man Factors, Inc. (MFI).

The review and analysis effort involved a repetitive examination of MIL-STD-1472B from the points of view indicated earlier, i.e., those representative of the following stated objectives:

- a. Compliance level review
- b. Conflicts analysis
- c. New products analysis
- d. Criterion validation analysis

The Ad Hoc review committee was utilized in each of these analyses in order to take full advantage of the broad range of experience represented by committee members. Members were selected on the basis that they were working in the industrial setting and therefore were faced with the specific problem of seeing to it that their company gave appropriate attention to human factors in hardware system development. Such individuals not only were trained human factors specialists, but each represented many years of practical experience in working with the basic human engineering standard for military equipment development, viz., MIL-STD-1472.

The method used to elicit assistance from the Ad Hoc Committee members was for MFI to develop preliminary results for each of the analytic steps and then to submit these to them for their critical review and comment. Therefore the ultimate recommendations submitted in the Addendum to this report actually represent not just the output of the study contractor but, rather, the collective recommendations of a much larger group of specialists highly representative of the military systems development community as a whole.

## RESULTS

The primary result is, of course, a fairly comprehensive set of proposed modifications for specific sections plus a few individual paragraphs in other, related sections. The primary sections include the following:

a. CONTROL/DISPLAY INTEGRATION - It was considered important and necessary to expand this section in order to deal with a number of integration problems that either were missing in the present Standard or else were treated so lightly that the particular topics were not representative of the scope and broad applications need of the stated requirement. A good example was the inadequate treatment of the subject of feedback. Another area that was expanded considerably was that of control-display movement relationships because the original material did not adequately address unique aspects of different system applications (e.g., aircraft, automotive systems, ships and submersibles, etc.). A third area that was expanded was the control-display movement ratio section.

b. VISUAL DISPLAYS - The principal areas for expansion in this section related to various display types that were not covered in the original set of requirements and, in particular, new requirements to cover new display products such as LCD's, LED's, plasma and other similar display devices or techniques now in broad use in military systems. Perhaps the most significant expansion, however, occurred in the section dealing with CRT's, not only because the original provided extremely limited guidance but also because the wide use of CRT's presents a major visual display interface design problem for a major share of current military systems.

c. AUDIO DISPLAYS - A considerable expansion of this section was considered necessary just as in the case of the CRT since the original section was minimally representative of the guidance needed to provide adequate audio systems design and development.

d. CONTROLS - The major observation in reviewing and analyzing this section was that the requirements in the original standard were considerably deficient in terms of addressing all the types of controls currently being used in various systems (i.e., aircraft, ships, submarines, automotive vehicles, and other support systems). A special deficiency was noted with respect to keyboards, data pick-off devices, and various foot-operated controls. Although some conflicts were discovered between MIL-STD-1472B and other military standards and specifications in the display area, conflicts appeared to be especially numerous with respect to the controls section. Therefore, this section of the Addendum volume contains a considerable number of changes to expand original requirement

statements and to add new requirements to cover all of the control types not included in the original Standard. Included are a number of suggested illustrations and new tables to provide a more comprehensive and less confusing coverage of all of these controls. It was also found that there was a considerable lack (in the present Standard) of appropriate criteria to accompany the proposed requirements, especially with respect to specifying control resistance limits. A major deficiency occurs because current criteria deal almost exclusively with the male operator and little, if any, equivalent female data apparently is available. Notice 2 for MIL-STD-1472 provides considerable new data on females but not specifically in the area of control resistance.

e. Other Sections - There are, of course, individual requirements relating to operator/maintainer display, control and manipulative interface designs (e.g., handles, fasteners, connectors, etc.) in several "other" sections of MIL-STD-1472B. Minor modifications and/or additions were considered appropriate in several of these. However, there appeared to be no need for modifications of the magnitude described in the above paragraphs.

It should be noted within the context of "results" that, while reviewing MIL-STD-1472B to make sure that all facets of display and control were adequately covered, other deficiencies were observed in several other sections. These should be addressed at some time in the near future to develop recommendations similar to those presently suggested for the display and control sections of the Standard. Deficiencies and possible errors especially noted occur in the sections on GROUND WORKSPACE DESIGN, DESIGN FOR MAINTAINABILITY, SMALL SYSTEMS AND EQUIPMENT, OPERATIONAL AND MAINTENANCE GROUND/SHIPBOARD VEHICLES, AEROSPACE VEHICLE COMPARTMENT DESIGN, and HAZARDS AND SAFETY.

Finally, it is our observation that the present index is highly inadequate and that the overall organization of the Standard leaves much to be desired. Our main concern with respect to the index is that it does not provide a consistent design-requirement perspective. Although the entry words probably are adequate for the experienced human factors specialist, they are less appropriate for the typical engineer or designer--and especially for the various types of designers (i.e., aircraft, automotive, shipboard, etc.). Our major objection to the overall organization of the Standard is that it is not consistent throughout the document and that many of the sections do not follow an expected series of related topics. This has made it extremely difficult in this study to: (1) find pertinent topics; (2) make sure that a proposed modification is compatible with all the other, related, paragraphs; (3) add new material in a logical place (i.e., the material could go into several places); and (4) to minimize redundancy because of the arbitrary way in which some related topics are broken up.

## RECOMMENDATIONS

Detailed recommendations for modifying specific sections of MIL-STD-1472B are provided in a separate Addendum to this report. This separate document is entitled, "Recommended Modifications to MIL-STD-1472B; Selected Sections on Controls, Displays and Related Hardware".

The present section therefore deals with independent and somewhat general recommendations (over and above those in the Addendum) that should be given serious consideration in the near future.

### a. Research Related to Control-Display Requirements

- (1) Strength/Force Data - Human strength data and related specifications for control resistance are considered highly suspect in terms of the criteria presented in both this and other military standards and specifications. There is a need, first, to develop data on female strength. Although we have reviewed numerous studies dealing with female strength, comparisons between male and female operators, and isolated applications criteria, the lack of consistency among these studies (not to mention the inappropriateness of the populations studied) lead us to question many of the force criteria currently specified in military documents.

It is therefore recommended that a systematic set of experiments be conducted to address the unique design questions that face system designers. Although laboratory-based studies could provide much of this needed information, it appears desirable that more operationally-oriented experiments be performed. For example, it does little good to provide a table of maximum forces that can be applied to a foot pedal from different knee angle positions. The real problem is pushing a brake pedal, rudder pedals or an accelerator pedal through a specified travel pattern, considering the variables presented by the dynamic characteristics of an auto or truck, a tank, an airplane or other vehicle in the range of operating environments--not to mention the effects of clothing or footwear, or the effects of "startle," "alertness," "fatigue" or other motivational factors.

Equally questionable are present criteria provided for manual controls, including torque limits for various rotary controls, resistances for levers

of various types, resistances for keyboard keys and common push buttons or thumbwheels. Present criteria provide too simplistic interpretations, i.e., they do not represent differences due to the position of the controls, whether one might be wearing gloves or mittens, whether the control is operated intermittently or repeatedly, and/or whether the control is operated by an index finger, the heel of the hand, and so on. The majority of the present criteria appears to be "best estimated" based on contemporary hardware characteristics.

- (2) Special Visual Displays - Research is needed to define further the critical characteristics of several contemporary display devices including CRT's, LCD's and LED's. For example, current criteria relating to selection and use of CRT's are state-of-the-art related. Although this is understandable, recent advances in this state of the art, provide ample evidence that such criteria are "picked up" variously from specific design solutions (in some cases supported by a limited research study) and not from a systematic experimental examination of the key issues that are so important to the designer of a new system.

In the present study, we found considerable disagreement regarding many parameters and criteria for the design and/or selection of CRT's. We utilized the services of a radar expert in producing the recommendations resulting from this study. It was disconcerting to have that individual (with all of his experience) admit that he probably learned more from this exercise than he was able to offer in the way of expertise. Thus, in spite of a considerable improvement in the section over what it was, we feel that a more extensive study should be made of CRT's, including experimental research to derive performance-tested criteria.

- (3) Keyboards - We found a very limited amount of information regarding the design and use of keyboards except for such superficial things as key spacing, (questionable) resistance data, and/or keyboard or keypad organization practice.

The principal problem area that appears to need resolution is the confusion regarding: (1) keypads organized like calculators or telephone arrays; (2) use of alphanumeric keyboard for numeric entry in lieu of a ten-keypad; and (3) considerable confusion about keypad formats with respect to auxiliary keys (e.g., zero, "entry", "clear", etc.). The

only keypad performance data we found support for was the telephone format, yet the general practice for data entry keypads follows traditional calculator format. However, in the latter case we find a number of computer manufacturers offering keypads that revert to the telephone format. In our opinion, there may be a better format than either one, viz., a two-row format using 1 to 9 in the top row and 0 to '0' in the second row. Although we suspect this may have been evaluated by someone, we could not find any supporting documentation.

It is recommended that additional research be performed to determine all of the "use" and "format" criteria based on operator performance for a wide range of applications. Although it might seem that a change might cause considerable disruption as far as industry is concerned, actually all that really would be required would be changing key caps--unless of course, the keypad format determined best turns out to be a two-by-five or other arrangement.

- b. Additional Biomechanical Research - As already noted there is a question as to the validity or credibility of many of the force-related criteria currently provided in MIL-STD-1472B (as well as in other engineering standards). We have observed, for example, that current force criteria do not reflect the needs of the military female. In addition, many criterion values are based on "experting" rather than on performance-related data. And many of the criteria appear purposely to have been made very general due to the complexities involved in taking an application-by-application approach.

It is probably true that in some cases experting may be adequate. But without some better background information (based on performance research) it is hard to tell whether expert guesses are adequate or not. A good example of this is the lack of specific data on the forces for weapon or tool triggers. Interrogation of a wide range of individuals who should know of any research data regarding trigger forces yielded a confusing set of opinions on the subject, but principally the fact that no specific research data are available. Another critical area is the lack of force criteria associated with special controls such as brake pedals. Recent studies indicate that maximum leg strength has little to do with a desired force limit recommendation. That is, because of the complex, dynamic nature of brake usage--manual vs. powered, large vs. small vehicles, etc.--a simple admonition to "keep within strength envelopes produced by static laboratory studies" is entirely inadequate for design guidance.



In view of the above it is recommended that additional research be conducted to determine force-related requirements for all of the key applications that MIL-STD-1472B addressed. It is recognized that this recommendation may involve a rather extensive program involving considerable time and expense. But until such research is accomplished we will continue to be faced with arguments about the criterion values we are using.

- c. General Aviation Display Conflicts - Again as noted earlier, there are major conflicts between the manner in which aircraft instruments are designed and the basic principles espoused by MIL-STD-1472B (as well as most other human engineering guides, handbooks, and research reports). Historically, aircraft controls and displays were somewhat outside the responsibility of human factors specialists at Wright-Patterson except for an advisory role. Many battles occurred between the engineering group responsible for control-display hardware and the human factors groups, and although some human engineering input was slipped-in now and then, general underlying design philosophy resisted any major inroads.

This stalemate has been further amplified by the aircraft instrument manufacturers who typically continue their own traditions. Our initial impulse has been to "fall in line" as has been done in the past. That is, as the present Standard does, to accept the aircraft practices by exception and merely refer to other engineering standards that deal with specific instruments. Upon reflection, however, we realized we cannot in fairness tell one group of designers to follow good human engineering practice and at the same time tell another group to do as they please! Doing so implies that we really do not have solid support for our human engineering principles and criteria.

We therefore recommend that steps be taken to, first, open the subject up to debate. And, second, follow this with a plan for a systematic program for realigning aircraft display philosophies to coincide with recognized human engineering practices. This may, of course, involve some extensive research to support realignment decisions. A good start might be to call a conference of cognizant agencies and persons to review the problem and to develop recommendations for its resolution.

- d. Update of Other Sections - Although this study did not address sections of the Standard unrelated to controls and displays (or related manipulative components), our comprehensive reviews of the various sections

emphasized to us that many of them also need revision, particularly those dealing with equipment packaging, consoles, ground systems, maintainability and, most importantly, safety.

- e. Separate Human Engineering Standards - The size of the present standard already is rather large and therefore somewhat cumbersome compared to most other standards and specifications. With the proposed modifications resulting from this study it becomes obvious that if they are all accepted and incorporated in a new revision the resulting document will become even more unwieldy. It therefore appears desirable to consider, at some time in the future, some type of separation of requirements into several separate and more manageable standards dealing with specific topic areas (e.g., Controls and Displays, Equipment Packaging, Aircraft Crew Stations, Ground Vehicle Crew Stations, Shipboard Crew Stations, etc.).

## APPENDIX A

### BIBLIOGRAPHY

The following list of references were utilized during the study to provide guidance in evaluating original requirements in MIL-STD-1472B (and Notices 1 and 2) and preparing modification recommendations.

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## APPENDIX B

### DEPARTMENT OF DEFENSE DOCUMENT REFERENCES

The following documents were reviewed and analyzed for potential conflicts with MIL-STD-1472B. Although a considerable number of additional documents were also reviewed, documents listed here were the ones actually containing human-system interface requirements--making this list useful for anyone responsible for maintaining continued compatibility between MIL-STD-1472B and other military standards and specifications.

MIL-STD-12C Abbreviations for use on Drawings, Specifications, Standards and in Technical Documents

MIL-STD-101B Color Code for Pipelines and for Compressed Gas Cylinders

MIL-STD-104B Limits for Electrical Insulation Color

MIL-STD-129H Marking for Shipment and Storage

MIL-STD-188C Military Communication System Technical Standards

MIL-STD-195 Marking of Connections for Electric Assemblies

MIL-STD-203F Aircrew Station Controls and Displays: Assignment, Location, and Actuation of, for Fixed Wing Aircraft

MIL-STD-250D Aircrew Station Controls and Displays for Rotary Wing Aircraft

MIL-STD-411D Aircrew Station Signals

MIL-STD-415D Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for

MIL-STD-450B Signs for Contaminated or Dangerous Areas

MIL-STD-681B Identification Coding and Application of Hook Up and Lead Wire

MIL-STD-783C Legends for Use in Aircrew Stations and on Airborne Equipment

MIL-STD-808 (USAF) Finishes, Protective, and Codes, for Finishing Schemes for Ground and Ground Support Equipment

MIL-STD-850B Aircrew Station Vision Requirements for Military Aircraft

MIL-STD-882A System Safety Program Requirements

MIL-STD-884C Electronically or Optically Generated Displays for Aircraft Control and Combat Cue Information

MIL-STD-1132A Switches and Associated Hardware, Selection and Use of

MIL-STD-1179A Lamps, Reflectors and Associated Signaling Equipment for Military Vehicles



MIL-STD-1180 (AT) Safety Standards for Military Ground Vehicles

MIL-STD-1247B Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft Missile, and Space Systems

MIL-STD-1280 Keyboard Arrangements

MIL-STD-1333A Aircrew Station Geometry for Military Aircraft

MIL-STD-1343 (NAVY) Glossary of Terms for Electronic and Weapons Control Interface Functions (Naval Ship Combat Systems)

MIL-STD-1348 Knobs, Control Selection of

MIL-STD-1353A Electrical Connectors and Associated Hardware, Selection and Use of

MIL-STD-1365 General Design Criteria for Handling Equipment Associated With Weapons and Weapon Systems

MIL-STD-1515A Fastener Systems for Aerospace Applications

MIL-STD-1555 Aircrew Station Displays and Associated Equipment, Definitions of

  

MS 21027 Switch, Toggle, Positive Break--Level Lock--Miniature, Toggle Sealed, Solder Lug, Double Pole, .469 Mounting Bushing

MS 21359 (USAF) Knobs-Control, Aluminum Alloy (Round, Concentric, Pointer, Spinner, Slotted, Bar, Locking Shaft Hole, and Knob Locks)

MS 21385 (USAF) Knobs-Tactile Series, Illuminated and Non-Illuminated

MS 25010 Light, Panel - Plastic Plate Lighting

MS 25165 Knob, Pointer, Illuminated, Small

MS 25166 Knob, Pointer, Illuminated

MS 25167 (ASG) Knob, Round, Small

MS 25168 (ASG) Knob, Round

MS 25169 (ASG) Knob, Bar, Small

MS 25170 (ASG) Knob, Bar

MS 26521 Handles, Control, Aircraft Landing Gear

MS 26523 (ASG) Handles, Control, Aircraft Fire Extinguisher

MS 27202 (ASC) Indicator, Position, Landing Gear, Symbol-Indicating, Integrally Lighted

MS 28112 (WEP) Instrument, Basic Standard Arrangement for Fixed Wing Aircraft

MS 33558 (ASC) Numerals and Letters, Aircraft Instrument Dial, Standard Form of

MS 33585 (ASC) Pointers, Dial, Standard Design of Aircraft Instrument

MS 33634 Instrument Arrangement, Engine, Standard, Basic for Fixed and Rotary Wing Aircraft

MS 33636 (ASC) Measurement, Units of, For Aircraft Instruments

MS 33739 Aircraft Markings, Servicing and Precautioning

MS 33785 Instrument Arrangement, Flight, Standard, Basic for Fixed and Rotary Wing Aircraft

MS 51113 Switch, Vehicular Lights: 24 Volt DC; (Waterproof)

MS 51399 (AT) Instrument Cluster: Automotive, Tactical Wheeled Vehicle, (W/O Air)

MS 53003 (AT) Instrument Cluster: Automotive, Tactical Wheeled Vehicle, 5 to 10 Tons Capacity (With Air)

MS 87017 Switches (Arrangement and Functions) Grip Assembly, Cyclic Controller, For Installation in Helicopters

MS 91522 Knob, Control, Crank, Metal

MS 91524 Knobs Control, Short Bar, Metal and Plastic

MS 91525 Knobs, Control, Bar, Metal

MS 91528 Knobs-Control, Plastic (Round, Concentric, Pointer, Spinner, Spinner Slip Clutch, Bar, Tactile, Knob Lock Pointer, and Knob Locks)

MS 91531 Knobs, Control, Round, Plastic (With Fluted Grip)

MIL-A-15303N (SHIPS) Audible Signals: Alarms, Bells, Buzzers, Horns, Sirens, and Electronic Shipboard

MIL-A-25719A (USAF) Accelerometer, Aircraft, Pilot's Warning, Type MA-1

MIL-A-MIL-A-25165B (ASG) Aircraft Emergency Escape System, Identification of

MIL-B-8568B Binoculars, Prismatic, Hand-Held (For Aeronautical Use) (7 x 50 and 6 x 42 (Wide Field))

MIL-B-8584C Brake Systems, Wheel, Aircraft, Design of

MIL-B-17311 (SHIPS) Binocular, Hand-Held, For Marine Use

MIL-B-23306A (SHIPS) Binocular, Ship, 20-Power, and Accessories

MIL-B-46334C (MU) Binocular, Infrared: M18

MIL-C-25050A (ASG) Colors, Aeronautical Lights and Lighting Equipment, General Requirements For

MIL-C-60618B (MU) Counter, Rotating, Mechanical, Direct Drive: 8587543 (3200 MIL Reset)

MIL-C-6781B (ASG) Control Panel: Aircraft Equipment, Rack or Console Mounted

MIL-C-8779D Colors, Interior, Aircraft, Requirements for

MIL-C-25969B (USAF) Capsule Emergency Escape Systems, General Requirements For

MIL-C-29025A (TD) Communication Systems For Training Devices General Specification For

MIL-C-87952 Counter, Electronic, Digital Readout 18 GIGAHERTZ (GHZ CONTINUOUS WAVE (CW))

MIL-D-28728/1A Dial, Control, Multiturn Counters 15-Turn Counter, Concentric

MIL-D-28728/2A Dials, Control, Multiturn Counters 10-Turn Counter, Concentric (1.250 Inches High)

MIL-D-28728/3A Dial, Control, Multiturn Counters 10-Turn Counter, Concentric (1.810-inch Diameter)

MIL-D-28728/4 Dial, Control, Multiturn Counters 10-Turn Counter, Concentric

MIL-D-28728/5 Dial, Control, Multiturn Counters 10-Turn Counter, 3-Digit

MIL-D-28728/6 Dial, Control, Multiturn Counters 10-Turn Counter, 3-Digit, Illuminated

MIL-D-28728/7 Dial, Control, Multiturn Counters 100-Turn Counters, 4-Digit

MIL-D-28728/8 Dial, Control, Multiturn Counters 10-Turn Counter, Concentric (.875 inch Diameter)

MIL-F-8785B (ASG) Flying Qualities of Piloted Airplanes

MIL-F-18372 (Aer) Flight Control Systems: Design, Installation and Test of, Aircraft (General Specification for)

MIL-C-81704 Glass, Aircraft Instrument, Lighting Wedge and Cover

MIL-H-8810B Handles, Control, Aircraft

MIL-H-46855B Human Engineering Requirements for Military Systems, Equipment and Facilities

MIL-H-83511 Headset-Microphone and Headset-Electrical (Medium Noise Attenuation, Hearing Protective), General Specification for

MIL-I-25931B (ASG) Indicator, Position, Landing Gear, Symbol-Indicating, Integrally Lighted

MIL-I-27197B (USAF) Indicator, Airspeed, Mach Number and Maximum Allowable Speed

MIL-I-38139C (USAF) Indicator, Vertical Velocity AAU-18/A, Integrally Lighted

MIL-I-81387A (AS) Indicators, Liquid Oxygen Quantity

MIL-I-81400 (AS) Instruments, Aircraft, General Specification For

MIL-I-81663 (AS) Indicators, Built-In-Test (BIT), General Specification For

MIL-I-82356 Instruments, Simulated, For Aircraft Training Devices; General Specification For

MIL-I-83287/2A Indicators, Fault Locating, Flag Indicating, Electrical Reset

MIL-I-83287D Indicators, Fault Locating, General Specification For

MIL-I-83287/4 (USAF) Indicators, Fault Locating, Flag Indicating, Mechanical Reset

MIL-I-83452A Indicator, Tape Type, General Specification For

MIL-K-3926B Knobs, Control (For Use With Electronic, Communications, and Allied Equipment)

MIL-K-48213 (MU) Knob, Setting

MIL-K-50889 (MU) Knob, Setting

MIL-K-25049B (ASG) Knobs, Control, Equipment, Aircraft

MIL-L-3976B Lights, Marker, Clearance (Service and Blackout)

MIL-L-5057E Lights, Instrument, Individual, General Specification For

MIL-L-5667B (USAF) Lighting Equipment, Aircraft Instrument Panel, General Specification For Installation of

MIL-L-6503H Lighting Equipment, Aircraft, General Specification For Installation of

MIL-L-7961B Lights, Indicators, Press to Test

MIL-L-18276C Lighting, Aircraft Interior, Installation Of

MIL-L-25142A Luminescent Material, Clourescent

MIL-L-25467D Lighting, Integral, Red, Aircraft Instrument, General Specification For

MIL-L-27160C (USAF) Lighting, Instrument, Integral, White General Specification For

MIL-L-006730C (AS) Lighting Equipment; Exterior, Aircraft (General Requirements for)

MIL-M-5755B Mirror, Rearview, Nonmagnetic, General Requirements For (For Aeronautical Use)

MIL-M-18012B Markings For Aircrew Station Displays Design and Configuration Of

MIL-M-60172 (MU) Manual Keyboard: 10526191

MIL-M-8555B Missiles, Guided: Design and Construction General Specification For

MIL-M-10304E Meters, Electrical Indicating, Panel Type, Ruggedized, General Specification For

MIL-M-11745B (ME) Marking and Labeling of U.S. Army Marine Craft

MIL-M-1321A (SigC) Marking of Electronic Items

MIL-M-16034A Meters, Electrical-Indicating (Switchboard and Portable Types)

MIL-M-46728B Mirror Assembly, Rearview: Automotive, Exterior Mounting

MIL-M-60903 (MU) Marking of Electrical Wires and Cables

MIL-N-85005A (AS) Navigation Display Set, AN/ASN-124

MIL-P-514D Plates, Identification, Instruction and Marking, Blank

MIL-P-7788E Panels, Information, Integrally Illuminated

MIL-S-22710/11D Switches, Rotary (Printed Circuit) (Thumbwheel Switch Assembly, Integral Bezel, Nonsealed, Illuminated or Nonilluminated), Style SRPCH

MIL-S-9320C Signal, Warning, Audible, For Headset, Type MA-1

MIL-S-22885/9J Switch, Push Button, Illuminated, 4-Lamp, Solid Mount, (Modular Constructed)

MIL-S-22885/10F Switch, Push Button, Illuminated Indicator Light For, Modular, 4-Lamp

MIL-S-22885/12D Switch, Push Button, Illuminated, Cap, Color Filter

MIL-S-22885/58C (EC) Switch, Push Button, Illuminated, 2-Lamp, Solid Mount, 3 Amperes, Unsealed

MIL-S-22885/59A (EC) Switch, Push Button, Illuminated, 2-Lamp, Lens Arrangements For

MIL-S-22885/67E Switches, Push Button, Illuminated, 4-Lamp, 0.75 Square, 7 Amperes, Electromagnetic Interference Shielded

MIL-S-22885/70B (EC) Switch, Push Button, Illuminated Color Filter

MIL-S-22885/80C (EC) Switch, Push Button, Illuminated, 4-Lamp, Solid Mount, RFI Shielded, Moisture Sealed, High Impact Shock Resistant

MIL-S-24187/6 (SH) Switch Assemblies, Linear Movement, Manual and Remote Operation, Snap-Action, Style SLS

MIL-S-24187D (SH) Switch Assemblies, Linear Movement, Manual and Remote Operation, General Specification For

MIL-S-58095 (AV) Seat System: Crashworthy, Non-Ejection, Aircrew, General Specification For

MIL-S-81771A (AS) Seats: Aircrew, Adjustable: Aircraft General Specification For

MIL-T-23991E Training Devices, Military; General Specification For

MIL-T-9906A Tape, Aircraft Tubing Identification Marker (Non-Corrosive, Heat, Cold, and Solvent Resistant)

FED SPEC GG-G-66b Gage, Pressure, Dial Indicating

FED SPEC GG-G-76D Gages, Pressure and Vacuum, Dial Indicating  
(For Air, Steam, Oil, Water, Ammonia, Chloro-Fluoro Hydrocarbon Gases,  
and Compressed Gases)

FED SPEC UU-D-171B Decals

FED STD No. 3 Colors, Aeronautical Lighting

FED STD No. 186 Marking of Valves, Fittings, Flanges, and Unions  
Used in Nuclear Reactor Systems

FED TEST METHOD STD No. 406 Plastics: Methods of Testing

AIR STD 10/2E Units of Measurement

AIR STD 10/6D Numerals and Letters for Aircrew Station Displays

AIR STD 10/8C Vertical Speed Indicators

AIR STD 10/9A Machmeters

AIR STD 10/12E Operation of All Controls and Switches at Aircrew  
Stations in Fixed Wing and Rotary Wing Aircraft

AIR STD 10/14D Grouping of Electrical Swtiches in Fixed Wing  
Aircraft

AIR STD 10/15K Location and Actuation of Airframe Controls in  
Fixed Wing Aircraft

AIR STD 10/19E Illumination of Aircrew Stations

AIR STD 10/20F Location, Actuation and Shape of Airframe Controls  
for Rotary Wing Aircraft

AIR STD 10/23D Emergency Control colour Schemes in Fixed Wing and  
Rotary Wing Aircraft

AIR STD 10/25F Location and Arrangement of Engine Instruments in  
Aircraft

AIR STD 10/30F Aircrew Station Warning Cautionary and Advisory Signals in Fixed Wing and Rotary Wing Aircraft

AIR STD 10/38B Principles of Presentation of Information

AIR STD 10/40A Location and Actuation of Lift/Thrust Controls for VTOL Aircraft Other Than Helicopters

AIR STD 10/41A Airspeed Indicators

AIR STD 10/42B Attitude Indicators

AIR STD 10/47 Nomenclature in Aircrew Stations

AIR STD 51/2A Emergency Markings

AIR STD 10/53B External Vision From Aircrew Stations

AIR STD 10/57 Vertical Scale Flight Instruments

AIR STD 11/1F Aircraft Servicing/Hazard Markings

AIR STD 65/3B Marking of Airfield Obstructions

NAT STD 3109 Symbol Marking of Aircraft Servicing Points

NAT STD 3153 Aircraft Navigation and Anti-Collision Lights

NAT STD 3154 Aircraft Formation Lights

NAT STD 3158 Day Marking of Airfield Runways and Taxiways

NAT STD 3217 Operation of Controls and Switches at Aircrew Stations

NAT STD 3218 Location, Actuation and Shape of Engine Controls and Switches for Fixed Wing Aircraft

NAT STD 3219 Location and Grouping of Electrical Switches in Fixed Wing and Rotary Wing Aircraft

NAT STD 3220 Location, Actuation and Shape of Airframe Controls for Fixed Wing Aircraft

NAT STD 3221 Automatic Flight Control System (AFCS) in Aircraft - Design Standards and Location of Controls

NAT STD 3224 Aircrew Station Lighting

NAT STD 3225 Location, Actuation and Shape of Airframe Controls for Rotary Wing Aircraft



NAT STD 3230 Emergency Markings on Aircraft  
 NAT STD 3322 Turn and Slip Indicators  
 NAT STD 3329 Numerals and Letters in Aircrew Stations  
 NAT STD 3341 Emergency Control Colour Schemes  
 NAT STD 3346 Day Marking of Airfield Obstructions  
 NAT STD 3359 Location and Arrangement of Engine Instruments in Aircraft  
 NAT STD 3449 Vertical Scale Tape Indicating Flight Instruments  
 NAT STD 3640 Attitude Director Indicators  
 NAT STD 3451 Integrated Machmeter and Airspeed Indicator  
 NAT STD 3593 Numbering of Engines and Their Associated Controls and Displays in Aircraft  
 NAT STD 3643 Coating, Reflection Reducing For Glass Elements Used in Aircraft Station Displays  
 NAT STD 3692 Location and Actuation of Thrust Vector Controls for VSTOL Aircraft Other Than Rotary Wing Aircraft  
 NAT STD 3675 Symbols On Land Maps, Aeronautical Charts and Special Naval Charts  
 NAT STD 3705 Principles of Presentation of Information in Aircrew Stations  
 NAT STD 3711 Airfield Marking and Lighting Colour Standards  
 NAT STD 3741 Horizontal Situation Indicators  
  
 HEL STD S-2-64A Human Factors Engineering Design Standard For Vehicle Fighting Compartments  
 HEL STD S-2-65 Human Factors Engineering Design Standard for Missile Systems and Related Equipment  
 HEL STD S-5-65 An Evaluation Guide for Army Aviation Human Factors Engineering Requirements  
 HEL STD S-6-66 Human Factors Engineering Design Standard for Wheeled Vehicles

HEL STD S-7-68 Human Factors Engineering Design Standard for  
Communication Systems and Related Equipment

TECH MEMO 21-62 Manual of Standard Practice for Human Factors in  
Military Vehicle Design

MIL-HDBK 141 Optical Design

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MIL-HDBK 600 Guidelines for Identification, Marking, Labeling,  
Storage, and Transportation of Radioactive Commodities

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IES Lighting Handbook (6th Ed), Illum Eng Soc., New York, N.Y.

AEROSPACE STANDARD AS 271A Aircraft Position Lights

AEROSPACE RECOMMENDED PRACTICE ARP 493 Knobs, Control Aircraft,  
Recommended Design

AEROSPACE RECOMMENDED PRACTICE ARP 498A Design, Layout, Criteria--  
Plastic Integrally Lighted Panels

SAE J585e Motorcycle Turn Signal Lamps  
SAE J585e Tail Lamps (Rear Position Lamps)  
SAE J586d Top Lamps  
SAE J578c Color Specification for Electric Signal Lighting Devices  
SAE J588e Turn Signal Lamps  
SAE J593e Backup Lamps  
SAE J595b Flashing Warning Lamps for Authorized Emergency,  
Maintenance and Service Vehicles  
SAE J589b Turn Signal Switch  
SAE J914a Side Turn Signal Lamps

FMVSS No. 101 Control Location, Identification and Illumination--  
Passenger Cars, Multipurpose Passenger Vehicles, Trucks and Buses

FMVSS No. 102 Transmission Shift Lever Sequence, Starter Interlock,  
and Transmission Braking Effect--Passenger Cars, Multipurpose Passenger  
Vehicles, Trucks, and Buses

ANSI C83.1 EIA Standard Colors for Color Identification and Coding

ANSI PH7.6 American National Standard Method for Calculation and  
Preparation of Projected-Image Size and Projection Distance Tables  
for Audio-Visual Projectors

ANSI S3.2 USA Standard Method for Measurement of Monosyllabic  
Word Intelligibility

ANSI S3.5 American National Standard Methods for the Calculation  
of the Articulation Index

ANSI X3.32 American National Standard Graphic Representation of  
the Control Characters of American National Standard Code for  
Information Interchange

ANSI X4.14 American National Standard Alphanumeric Keyboard  
Arrangements Accommodating the Character Sets of ASCII and ASCSOCR

ANSU Z53.1 American National Standard Safety Color Code for  
Marking Physical Hazards

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